PLASTICITY IN THE GERMINATION OF CALIFORNIA *Fragaria* SEEDS.—In two recent studies, substantial genetic variability was found in adults of *Fragaria chiloensis* and *F. vesca* for 25 quantitative traits and three enzyme systems (Hancock and Bringhurst, Amer. J. Bot. 65:795–803. 1978; Amer. J. Bot. 66:367–375. 1979). Most of these characters were shown to be significantly associated with various soil and climatic conditions, suggesting ecotypic differentiation. The purpose of this study was to determine if the germination responses of these species have also undergone ecotypic differentiation.

Eight diverse sites encompassing a broad range of environmental conditions were selected for study. These were McKinleyville (MK): near jct of Murray and Kelly roads N of McKinleyville; Pelican Beach (PB): 4 km S of the Oregon border; Dry Lagoon (DL): 6.4 km S of Redwood Creek Park; Enderts Beach (EB): along trail at end of Bluff Road; Pacifica Hilltop (PH): near jct of Copeland and Fassler avenues; Hecker Pass (HP): near Mt. Madonna along hwy 129; Point Sur (PS): headland north of Point Sur along hwy 1; and Año Neuvo (AN): beach at Año Nuevo Point.

From 15 Jul to 18 Aug 1975, runner plants were taken from at least 50 separate clones at each site, planted in 2000 cm^3 pots containing a sandy loam, and placed in a single greenhouse. They were fertilized, irrigated with deionized water, and protected from various pests and diseases as needed.

From the start of anthesis in March until its termination in August, pollen was transferred every three days among all open flowers in each population using a camel hair brush. Care was taken to keep the pollen of the various populations separate. As fruits ripened, they were squashed between two paper towels and their seeds were removed after drying for three days at room temperature. Seeds from at least 50 fruits of each population were mixed together and stored dry in envelopes at 5°C until the germination studies began six months later.

At equidistant points along the same transects used for plant collection, five soil samples were gathered from 5 cm beneath the soil surface and were stored at room temperature in open glass jars. The five soil samples from each collection site were blended to produce 8 bulked soil types. These soils were poured 1 cm deep into petri plates and three replicates of 50 seeds from each population were placed on each soil. A single soil and seed population was tested in each plate. The soils were saturated with water, covered with cellophane and randomly arranged in a growth chamber maintained between 20°C at night and 28°C at day, with 1300 ft-c and a 14 hr day/10 hr night photoperiod. Germination was recorded every two days for a total of 30 days (radicle emergence was used as the criterion for germination). Mean values for germination percentage and rate were calculated for each population. Significant groups at the 5 percent level were determined using a Duncans Multiple Range Test (Steel and Torrie, *Principles and procedures in statistics*. 1960). An arcsine transformation was performed prior to analysis of the germination percentage data.

The methods employed in the collection, storage, and germination of seeds generally resulted in high proportions of germinated seed. The ranges for each seed population on the various soils tested were: *F. chiloensis*: AN (.47–.90); PS (.50–.72); PH (.52–.92); MK (.57–.97); DL (.62–.97); and PB (.52–.95). *F. vesca*: PS (.67–.97); PH (.52–.97); EB (.72–1.00); and HP (.35–.82).

The results, however, offered little evidence of ecological differentiation for germination characteristics. The seed populations generally sorted into two to four significantly different groups with several populations often belonging to the same group. On their "native" soils, only 50 percent of the *F. chiloensis* and 75 percent of the *F. vesca* populations were in the group with the highest germination percentages, while 66 percent of the *F. chiloensis* and 50 percent of the *F. vesca* populations were in the fastest germinating group. These results were not far from what could be expected by chance. Furthermore, only 16 percent of the *F. chiloensis* and 25 percent of the *F. vesca* germinated more rapidly on their "native" soil than any other, while only 55 percent

of the *F. chiloensis* and 50 percent of the *F. vesca* populations had higher germination percentages on their native soils than others.

It is possible that little ecological differentiation was observed in our seed populations, because a critical selective factor was eliminated in the way we handled our soils. Parameters such as soil litter, temperature, soil surface microstructure, and allelochemicals are probably important and may have also affected the results.

We do know, however, that the lack of discrimination between the populations arose in spite of substantial variation in soil pH, salinity, and organic carbon content (Hancock and Bringhurst, op. cit.). After storage, the various soils had salinities ranging from 371–832 ppm, while pH varied from 5.11–7.20, and percent organic carbon values ranged from 0.13–5.97 percent. It seems likely, then, that the germination requirements of California populations of *Fragaria* are quite plastic for at least these parameters.

We thank several anonymous reviewers who insisted on making us see the truth.—JAMES F. HANCOCK, Department of Biology, University of South Carolina, Columbia 29208 and R. S. BRINGHURST, Department of Pomology, University of California, Davis 95616. (Accepted 28 Apr 1979.)

REVIEWS

A Primer of Ecological Principles: Book One. By RICHARD J. VOGL. 1978. xiii + 172 pp. Pyro Unlimited, Cypress, CA. $4.95.

A casual perusal of the table of contents might lead one to decide that this is yet another addition to the recent proliferation of texts on ecological theory. From the title alone one might be tempted to place this book on the shelf alongside Wilson and Bossert's *A Primer of Population Biology*. Both title and table of contents are, in this sense, misleading. This is not a run-of-the-mill ecology text. It is an attempt to present basic ecological principles—and their management implications—in clear concise language and in an interesting, light-hearted fashion. It is to Vogl's credit that he emphasizes the role of this volume as a supplement to field experience, which he, along with most practicing ecologists, considers the backbone of our science.

In format the book alternates pages of briefly-described ecological principles with pages of more or less apt quotations from a wide range of sources. This is initially a refreshing approach. The book is replete with quotable quotes (e.g., "Many scientists use statistics the way that drunkards use lamp posts; that is, they use them more for support than for illumination.") and offers many insights that will elicit knowing chuckles from experienced ecologists. The book is punctuated by rather charming and sometimes whimsical drawings—often with a strong American Indian influence. It is, however, a treatment with a viewpoint, and as such may not be well received by those not already of Vogl's primarily preservationist persuasion. Unfortunately, the businessman, rancher, miner, developer, for whom this book, in part, is intended, may consider this a radical treatise rather than a source of solid ecological information.

The introductory chapter presents a balanced perspective on the field of ecology. In addition to the standard definition of ecology, Vogl presents several "alternate definitions" that should hit close to home for many readers. An example: Ecology is "The study that takes natural things that are easy to comprehend and translates them into languages . . . that few can understand." There is an emphasis on the holism of ecology, on the importance of synthesis, interpretation, and speculation to meaningful ecological research. There follows an exhaustive listing of the branches of ecology. That many of these categories overlap might be unclear to the beginning student. The introduction to this section is overly critical of those who specialize within ecology.

Perhaps the most illuminating statement in Chapter II (General Ecological Principles) is that "there are no absolute principles or universal ecological laws other than those